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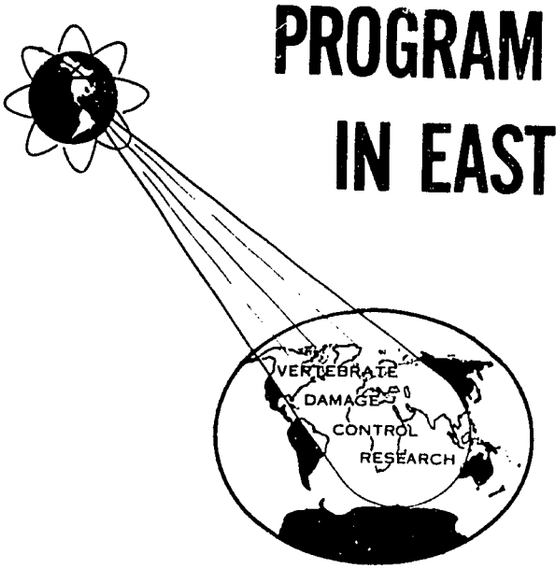

1972

Conducted by

Rodent Research Center
College, Laguna
Republic of the Philippines

and

U.S. Bureau of Sport Fisheries and Wildlife
Denver Wildlife Research Center

Sponsored by

U.S. Agency for International Development

A VERTEBRATE PEST MANAGEMENT WORKSHOP PROGRAM IN EAST ASIA
September 27 - November 17, 1972

Michael W. Fall, Glenn A. Hood, and John W. De Grazio

Cooperating Agencies

KOREA

Office of Rural Development

THAILAND

Ministry of Agriculture

PHILIPPINES

Rodent Research Center

Bureau of Plant Industry

University of the Philippines, College of Agriculture

UNITED STATES

Agency for International Development

Bureau of Sport Fisheries and Wildlife

Denver Wildlife Research Center

TABLE OF CONTENTS

ABSTRACT

Three twelve-day workshops on Vertebrate Pest Management were conducted in Korea, Thailand, and the Philippines by personnel of the Rodent Research Center (Philippines) and the Denver Wildlife Research Center. These programs were supported by the U.S. Agency for International Development and by the governments of participating countries. The major objectives of the workshops were to present the principles and strategies involved in protecting agricultural crops; to review, explain, and demonstrate the range of existing techniques; and to suggest ways of identifying and defining problems, quantifying damage, and organizing research on local problems. Classroom, laboratory, and field sessions contributed toward these goals. Eighty-five trainees from eight Asian countries participated in the program. With continuing support from their governments, these men and women can provide a valuable resource for dealing with complex agricultural pest damage problems.

ACKNOWLEDGEMENTS

The active cooperation, support, and encouragement of many people from the participating government agencies made possible the successful completion of this workshop program. We especially thank Mr. Ye Yang Kim, Mr. Amroong Dipapal, and Dr. Fernando Sanchez who had primary responsibilities for making exceptional program arrangements in Korea, Thailand, and the Philippines, respectively. We are particularly grateful to Dr. Soo Won Kang, Dr. Pyung Hooi Won, Dr. Joe T. Marshall, Jr., Dr. Sawart Ratanaworabhan, Mr. Jesus P. Sumangil, Mr. Richard R. West, and Mr. F. Nelson Swink, Jr., all of whom served as guest lecturers in the sessions. The patience and enthusiasm of the eighty-five trainees made our job most enjoyable.

INTRODUCTION

The problems of producing food for a rapidly growing world population while maintaining a clean, stable environment have increasingly involved conflict between man and animal pests. Although considerable effort has been expended in developed countries to solve local or regional vertebrate pest damage problems, national interest in such problems in the lesser developed countries is relatively recent.

Much of the published information on economic damage by vertebrates appears rather subjective, often exaggerating the intensity or extent of problems. However, it seems likely that rodent damage to rice ranges from 3 to 5 percent of annual production in several of the East Asian countries. By some accounts, storage losses (which are difficult to estimate) may be somewhat larger. Little is known about the degree of damage to crops other than rice and about that caused by birds. However, there are few small farmers in the rice growing regions of Asia that are not troubled to some extent with vertebrate pests. Sporadic pest outbreaks and unpredictable variation in the amount of damage from place to place and season to season make average damage figures almost meaningless to the farmer to whom failure of a small hectarage of rice may mean hunger for his family.

As man attempts to apply technology to increase food production, the variety and intensity of vertebrate pest problems will probably increase. Awareness of the economic impact of pest problems among governments is increasingly evident. In order to deal with these problems on a contiuing basis there is a need for the agricultural extension worker and farmer to rely on the help of technicians who have a broad understanding of local culture, animal biology, and agricultural ecology as well as the techniques of crop protection.

PEST MANAGEMENT

Pest management is a new term for an approach to pest control that some economic entomologists and wildlife managers have been using for many years. In agriculture, pest management refers to the procedure of intelligently designing a crop protection program that integrates a variety of control techniques selected in relation to the life systems of the pests, the ecology of the crop, and the economic constraints of control cost and crop value. Protection of crops rather than eradication of pest animals is the goal. The idea of selective management is extremely important because of local and seasonal variations in pest populations and crop susceptibility. Agricultural modernization, with its accompanying monotypic plantings, accelerated schedules, and improved habitats due to factors like irrigation, is bringing with it significant changes in the types of pest situations encountered. Higher yields and the investments in fertilizers, insecticides, and herbicides make the farmers' crop more valuable; increasing effort and interest are being devoted to crop protection throughout the developing world.

While the principles of pest management apply to alleviating the destruction caused by insects and plant diseases as well as rodents and birds, vertebrate pests present some special problems that may require somewhat different strategies. The principles of rodent population dynamics are generally well-known from many basic studies conducted in the temperate, developed countries. But the dynamic conditions of tropical lowland agriculture seem to produce many pest situations which are sporadic in occurrence, variable from place to place (even field to field) and highly unpredictable. In this context, an understanding of the ecological, cultural, and economic factors involved in a particular situation are as important to the development of a pest management system as the biological understanding of the pest itself.

ORIGIN

Recently, there has been an effort by several countries in Asia to begin adaptive research on their local vertebrate pest problems. The shortage of trained personnel and the diffuse sources of technical information have added to the local difficulties of understanding, planning, and organizing research and operational vertebrate management. The recurrence of similar problems and pest species in the region suggests that these countries can benefit from the identification of common goals. In order to reinforce the interest shown by the various countries and tostimulate regional dialogue on vertebrate pests, workshops were held in Korea, Thailand, and the Philippines with additional participants from Laos, Malaysia, Indonesia, Vietnam, and Nepal. (See Appendix A)

These workshops were conducted by personnel of the Philippine Rodent Research Center and the Denver Wildlife Research Center, under the sponsorship and funding of the Agency for International Development (PASA RA(ID) 1-67), and with the invaluable help and assistance of many biologists, agriculturists, and administrators in each country.

ARRANGEMENTS

Arrangements were made by personal contact between participating country agencies and local USAID officials. Participants were selected by local committees to represent country agencies with interest or active programs in pest research and operations. Local committees made arrangements for classrooms, laboratories, and audio-visual equipment and selected suitable areas for field demonstrations. The participating countries were supplied with a laboratory kit, traps, and animal cages to assist the initiation or continuation of laboratory and field studies. Participants received personal copies of appropriate books and reprints.

OBJECTIVES

The major objectives of the workshops were to present the principles and strategies involved in protecting agricultural crops; to review, explain, and demonstrate the range of existing techniques; and to suggest ways of identifying and defining problems, quantifying damage, and organizing research on local problems. Classroom, laboratory, and field sessions, as well as much informal discussion among instructors and participants, contributed toward these goals. The establishment of new professional relationships and international friendships among participants from various countries is anticipated to have a beneficial effct on future cooperative work and information exchange on common problems.

PROGRAM AND SCHEDULE

The first workshop was held at Suwon, Korea at the training facilities of the Office of Rural Development. The second program was held at the Ministry of Agriculture facilities on the campus of Kasetsart University at Bang Khen, Thailand. Students from Thailand and Laos attended the session. The third workshop was held in the new training section of the Rodent Research Center at the University of the Philippines in Los Banos. Trainees at this workshop came from Indonesia, Malaysia, Nepal, Philippines, and Vietnam. Numbers of participants and their names and addresses are shown in Appendices A and B.

The schedule for each workshop encompassed about twelve full working days; about seven days were spent in the classroom. In addition to lectures, slides, movies, handouts, and preserved specimens were used. Books and reprints of technical articles were available to each participant. There were also several local lecturers on each program. Two days of laboratory exercises included determination of LD_{50}'s, bio-assay tests, identification of rodent species, and preparation of museum specimens. About three days were spent infield exercises which included snap-trapping and live-trapping in ricefields and surrounding habitats, testing bait acceptance, making carcass examinations, and conducting damage surveys in rice. Demonstrations included bait preparation, field use of radio telemetry, and techniques for marking animals. Grain storage facilities were visited and inspected for rodent infestation by students at each location. The students also visited farms and local experiment stations where they had an opportunity to ask questions and compare their own experiences. While the workshops differed slightly, a composite schedule showing the sequence of most of the activities at the three workshops is shown in Appendix C.

In classroom lectures, the instructors aimed for a balance among basic subjects such as behavior, ecology, and economics and technical talks on materials, techniques, and data analysis. The concepts of pest

management and the interrelationships between agricultural production and crop protection formed themes to tie the diverse topics together. An annotated list of major lecture topics is shown in Appendix D.

EVALUATION

The opportunity to contact 85 enthusiastic trainees from 8 countries during the short period of 1 1/2 months was a stimulating experience for the instructors. The chance for students to compare experiences and ideas with co-workers and visiting participants in a framework of evaluation and planning provided for a great deal of interaction and lively after-hours discussion. Questionnaires filed by the participants and subsequent discussions suggested that most topics of interest were included to some degree in the program. Many suggested that a longer workshop might have been desirable, but such considerations need to be balanced with the number of students reached in a short period. The restriction of class size to about 25 seemed essential for effective work on field and laboratory exercises. Smaller classes might allow for more individualized work. While language differences resulted in a slower pace in all of the sessions, the opportunity to learn from one another probably more than balanced this problem for both students and instructors. We felt the majority of the students left the sessions with a better understanding of the difficulties to be encountered and some practical and potential means for improving crop protection. With continuing support from their governments, these students can provide a valuable resource for dealing with complex agricultural pest damage problems.

WORKSHOP PHOTOGRAPHS

Figure 1. Trainees in the Philippines discuss rice damage survey.

Figure 2. Korean trainees examine a rice field with damage caused by podemus agrarius.

Figure 3. Trainees look for rodent damage to stored rice during the Philippine sessions.

Figure 4. Korean trainees visit a local farm.

Figure 5. Preparations for laboratory work in Korea (ORD photo).

Figure 6. Philippine trainees make a carcass examination of a rice-field rat.

.gure 7. Setting traps for rodent population survey.

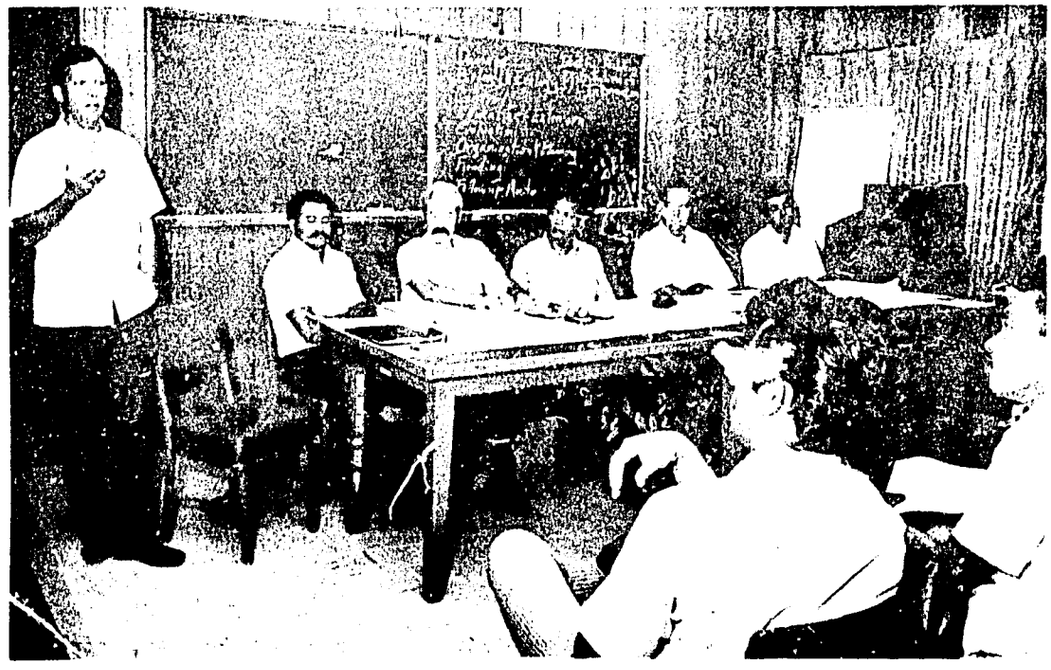

Figure 8. A panel discussion in the Philippines (BPI photo).

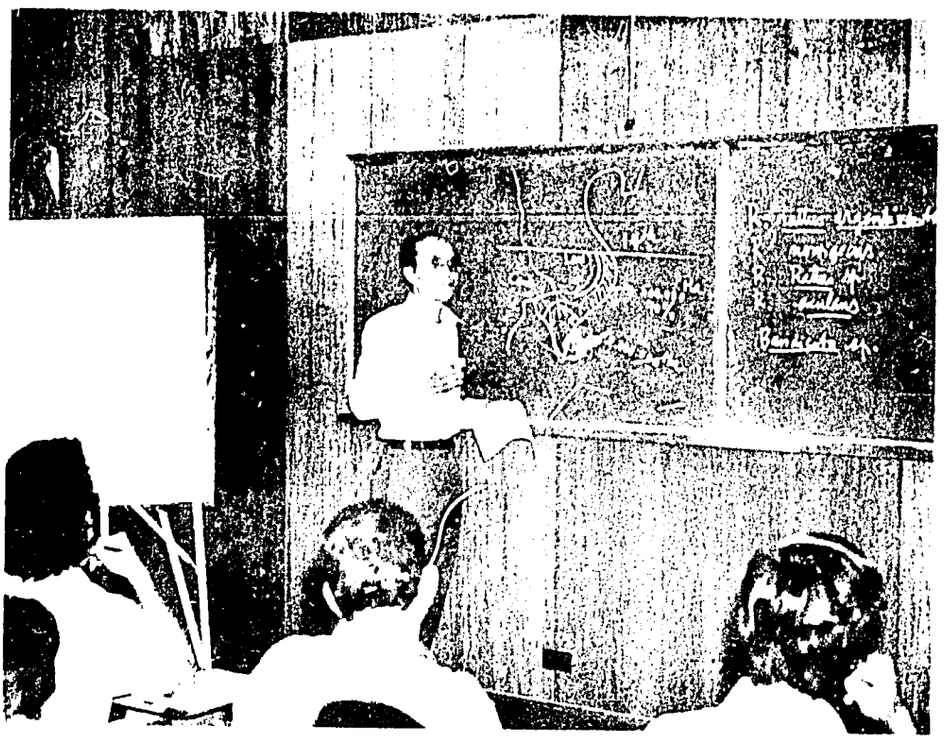

Figure 9. Mr. Nguyen Lang Duyen (Vietnam) explains the problems with agricultural pests in his country.

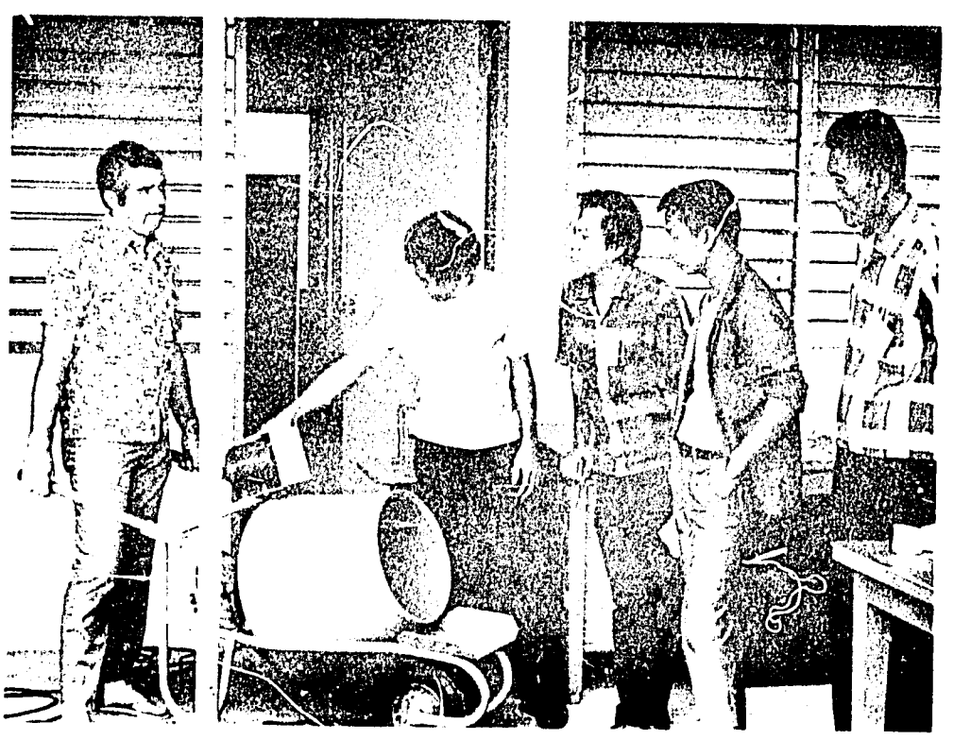

Figure 10. Trainees and instructor discuss the use of a cement mixer for preparing bait.

APPENDIX A

NUMBER OF TRAINEES FROM THE EIGHT COUNTRIES PARTICIPATING IN THE VERTEBRATE PEST MANAGEMENT WORKSHOPS

COUNTRIES	NUMBER OF PARTICIPANTS
Indonesia	3
Korea	25
Laos	3
Malaysia	1
Nepal	1
Philippines	29
Thailand	21
Vietnam	2
TOTAL ---	85

APPENDIX B

TRAINEES ATTENDING THE VERTEBRATE PEST MANAGEMENT WORKSHOPS

Workshop Host Country: Korea

COUNTRY REPRESENTED	TRAINEE	AGENCY
Korea	Kim, Yo Yang	Office of Rural Development, Suwon
	Lee, Kyung Hun	Office of Rural Development, Suwon
	Lee, Sang Suk	Office of Rural Development, Suwon
	Lee, Seung Chan	Office of Rural Development, Suwon
	Hwang, Sun Bok	Office of Rural Development, Suwon
	Sin, Yong Moo	Office of Rural Development, Suwon
	Park, Kyu Teak	Office of Rural Development, Suwon
	Jung, Myung Suk	Seoul City Rural Guidance Office
	Ko, Jea Hak	Pusan City Rural Guidance Office
	Yeon, Sang Yeul	Kyonggi Provincial Government Office, Suwon
	Kang, Chan Koo	Kyonggi Provincial Office of Rural Development, Buchun
	Chei, Chan Soon	Kangwon Provincial Government Office, Chunchun
	Kim, Ho Yong	Kangwon Provincial Office of Rural Development, Chunchun

COUNTRY REPRESENTED	TRAINEE	AGENCY
Korea	Kim, Jea Hi	Chung Buk Provincial Government Office, Chaeng Ju
	Yeon, Ki Suk	Chung Buk Provincial Office of Rural Development, Chaeng Ju
	Yoon, Ei Sang	Chung Nam Provincial Government Office, Taejun
	Kang, Soon Bong	Chung Nam Provincial Office of Rural Development, Taedug
	Koon, Woon Sik	Jun Buk Provincial Office of Rural Development, Iri
	Che, Kok Ki	Junnam Provincial Government Office, Kwang Ju
	Kim, Sun Kyung	Junnam Provincial Office of Rural Development, Kwang Ju
	Lee, Suk Hyon	Kyong Book Provincial Government Office, Taegu
	Pak, Yong Do	Kyong Book Provincial Office of Rural Development, Chilgok
	Sim, Jae Yong	Kyongnam Provincial Government Office, Pusan
	Lee, Beong Sun	Kyongnam Provincial Office of Rural Development, Pusan
	Hong, Sun Nam	Jeju Provincial Office of Rural Development, Jeju

Workshop Host Country: Thailand

Thailand	Kasem Tongtavee	Agricultural Technology Dept.
	Somchai Tangpoonpon	Agricultural Technology Dept.
	Panya Assawanggoon	Agricultural Technology Dept.
	Puangton Boonsong	Agricultural Technology Dept.

COUNTRY REPRESENTED	TRAINEE	
Thailand	Somboon Tangsakul	Agricultural Technology Dept.
	Kovit Pongsawang	Agricultural Technology Dept.
	Winai Juttacheun	Agricultural Technology Dept.
	Amroong Dipapal	Agricultural Extension Dept.
	Thongchai Margsiri	Agricultural Extension Dept.
	Sanay Sooksai	Agricultural Extension Dept.
	Vunnarong Laupradith	Agricultural Extension Dept.
	Samruan Dokmaihom	Agricultural Extension Dept.
	Nipan Prachantasen	Agricultural Extension Dept.
	Payuha Mannechote	Agricultural Extension Dept.
	Orawan Wuthijundarojana	Agricultural Extension Dept.
	Somchet Kulta-Uthai	Ministry of Public Health
	Soonthorn Buapath	Ministry of Public Health
	Pralom Sakuntanaga	Metropolitan City Municipality
	Krirkvit Jumtorn	Metropolitan City Municipality
	Somchetana Suntrakul	Metropolitan City Municipality
	Boonyarith Savamnol	Kasetsart University, Department of Entomology
Laos	Long	Rice Research Station, Salakhan, Vientiane
	Phao Sipha	Agricultural Extension Zone, Vientiane
	Khampiou Rattanavong	Agricultural Extension Zone, Prabang

Workshop Host Country: Philippines

COUNTRY REPRESENTED	TRAINEE	AGENCY
Philippines	Alberto M. Macanas	Bureau of Plant Industry Buluan, Cotabato
	Diego N. Prado	Bureau of Plant Industry Cotabato City
	Antonio L. de Joya, Jr.	Bureau of Plant Industry San Isidro, Nueva Ecija
	Vicente P. Tamondong	Bureau of Plant Industry Calapan, Oriental Mindor
	Manuel B. Sagaoinit	Bureau of Plant Industry Armas St., Manaoag, Pangasinan
	Romeo C. Dizon	Bureau of Plant Industry Iloilo City
	Amando B. Mollasgo	Bureau of Plant Industry Manila
	Renato S. Galang	Bureau of Plant Industry c/o Rodent Research Center College, Laguna
	Bernardo E. Marges	Bureau of Plant Industry c/o Rodent Research Center College, Laguna
	Lorenza Ferrer	Bureau of Plant Industry c/o Rodent Research Center College, Laguna
	Albert Hermano	Bureau of Plant Industry c/o Rodent Research Center College, Laguna
	Delio C. Tolentin	Bureau of Plant Industry c/o Rodent Research Center College, Laguna
	Agapito de la Paz	Bureau of Plant Industry c/o Rodent Research Center College, Laguna

COUNTRY REPRESENTED	TRAINEE	AGENCY
Philippines	Danilo C. Salich	Rodent Research Center College, Laguna
	Oscar F. Hernandez	Bureau of Plant Industry Baliuag, Bulacan
	Reynaldo H. Rafanan	Bureau of Plant Industry Molave, Zamboanga del Sur
	Alfonso F. Ortiz	Bureau of Plant Industry Zaragosa, Nueva Ecija
	Florante A. Oca	Bureau of Plant Industry Economic Garden, Laguna
	Isidro L. Lusero	Bureau of Plant Industry Tarlac, Tarlac
	Raquel Arancillo	Bureau of Plant Industry Iloilo City
	Domingo Caliwag	Bureau of Plant Industry San Andres, Manila
	Luz P. Castro	Parks and Wildlife Office Diliman, Quezon City
	Antonio T. Calimag	Parks and Wildlife Office Diliman, Quezon City
	Ruben A. Callo	Parks and Wildlife Office Diliman, Quezon City
	Pedro L. Alviola III	Department of Entomology UPCA, College, Laguna
	Florencio I.S. Medina	Philippine Atomic Energy Commission, Quezon City
	Jose C. Castillo	Bureau of Quarantine, Port Area, Manila
	Blanquita S. Soledad	Central Philippine University College of Agriculture Iloilo City

COUNTRY REPRESENTED	TRAINEE	AGENC
Philippines	Romeo V. Aquino	Agricultural Productivity Commission, Diliman Quezon City
Inddnesia	Satta Wigenasantana	Plant Protection Service Directorate of Agricultural Technique Pasarminggu-Jakarta Indonesia
	Sadji Partoatmodjo	Plant Protection Service Directorate of Agricultural Technique Pasarminggu-Jakarta Indonesia
	Boedi	Museum Zoology Bogor, Indonesia
Malaysia	Lam Yuet Ming	Malaysian Agricultural Research and Development Institute Bumbong Lima, Kepala Batas Province Wellesley, Malaysia
Nepal	B. Singh Thapa	Department of Agricultural Education and Research Development Entomology Section, Khumaltar Kathmandu
Vietnam	Nguyen Lang Duyen	Plant Protection Service General Directorate of Agriculture P. O. Box 427, Saigon
	Charles R. Brown	USAID ADFA Prod Saigon, Vietnam or USAID ADFA Prod APO 96243 San Francisco, California

APPENDIX C

COMPOSITE SCHEDULE FOR THE VERTEBRATE PEST MANAGEMENT WORKSHOPS

Day 1 Morning

Registration

Opening of Workshop

Review of Agricultural Pest Problems -- slides

Review of Country Pest Problems -- guest lecture

Afternoon

Introduction to Pest Management

Film: Rodent Biology

Principles of Ecology

Economic Mammalogy

Economic Ornithology

General Discussion

Day 2 Morning

Population Biology

Principles of Management

Review of Control Methods for Mammals

Review of Control Methods for Birds

Afternoon

Film: Blackbirds at Sand Lake -- Problem and Solutions

Review of Common Rodenticides

Visit to Local Experiment Station

Day 3 Morning

Review of Management Principles

Economics of Pest Management

Management Problems and Research Needs

Research Procedures

Discussion of Research on Rodent Damage to Hawaiian Sugarcane

Afternoon

Discussion of Research on Rodent Damage to Rice in the Philippines

Visit to Local Farm

Day 4 Morning

Behavior of Pests

Food Habits of Mammals

Food Habits of Birds

Laboratory Animal Care

Procedures for Laboratory Tests

determination of LD_{50} by gavage

conducting concentration-effect bioassays

Afternoon

Damage Assessment in Agricultural Crops

Laboratory Exercises

animal handling and gavage

preparation of baits and solutions

LD_{50} experiment on local species

concentration-effect bioassay on local species

General Discussion

Day 5 Morning

Laboratory Exercises continued

collection and analysis of data from experiments

Identification of Rats

Preparation of Study Skins

Afternoon

Problems of Field Baiting and Evaluation

Baits and Bait Application for Rodents

Baits and Bait Application for Birds

Population Indices, Estimates, and Census Techniques

General Discussion

Day 6 Morning

Visit to Local Extension Agency Facilities

Afternoon

Open

Day 7

Open

Day 8 Morning

Review and Discussion

Field Use of Telemetry

Demonstrations

weather-proofing traps

bait mixing procedures

experimental use of fluorescent bait

Community Programs

Day 8 (cont.) Morning

Film: Rodent Control

Discussion

Afternoon

Rodent Problems in Storage

Bird Problems in Storage

Visit to Grain Mill and Warehouse

Day 9 Morning

Country Reports -- class

Discussion of the Regional Aspects of Pest Problems

Planning for Field Activities

Afternoon

Field Activities

trap-line and trap-grid layout

rodent trapping

Day 10 Morning

Field Activities

run trap-lines

examination and necropsy of rodents

damage assessment in

Afternoon

Discussion

Field Activities

rodent trapping

Day 11 Morning

Field Activities

run trap-lines and collect traps

examination and necropsy of rodents

Afternoon

Analysis and Discussion of Data

Discussion and Review

Day 12 Morning

Vertebrate Pest Management -- Review and Summary

Panel Discussion of Continuing Work and Research Needs

Evaluation

Closing Ceremonies

APPENDIX D

ANNOTATED LIST OF MAJOR LECTURE TOPICS FOR THE VERTEBRATE PEST MANAGEMENT WORKSHOPS

Agricultural Pest Problems: review of agricultural damage caused by rodents, birds, and other animals throughout the world; illustrated with slides.

Country Pest Problems: review (by local scientists) of species identification and biology, damage problems, control research, and operational program in workshop host-country.

Pest Management: concepts of timed crop protection and integrated use of appropriate management techniques as distinguished from eradication and annual population reduction; need for problem definition, damage assessment, and consideration of economic and social constraints.

Ecology: Discussion of physical and biological factors, communities, and ecosystems as they affect agricultural pests; food webs; predation and competition; ecology of pests in relation to control strategies; the ricefield as an ecosystem.

Economic Mammalogy: kinds of mammals and pest situations; the rat as a mammal; growth, reproduction, and care of young; special adaptations; home range and territory; competition with man.

Economic Ornithology: characteristics and adaptations of birds; reproduction, flocking, and migration; ecology of crop damag situations; perspective on occasional pests and desirable species

Population Biology: population vs. individuals; the population as the

management unit; population growth and regulation; limiting factors and carrying capacity; annual reproductive patterns of tropical rats.

Principles of Management: management as an integrated, continuing approach to crop protection; manipulation of limiting factors and reduction of carrying capacity; timing and integration of control measures; need for biological information about pests and adaptive research on techniques and strategies.

Control Methods for Mammals: description, status, and application of control methods and materials for mammals, particularly rodents, including physical and mechanical approaches, toxicants and repellents, chemosterilants, biological and ecological materials and procedures

Control Methods for Birds: description, status, and application of bird control materials and procedures, including chemical repellents, fright-inducing agents and toxicants, resistant crop varieties, planting schedules, frightening devices, and physical protection.

Review of Common Rodenticides: discussion of characteristics, hazards, precautions, and use of commercial rodenticides with emphasis on locally available materials; modes of action; relative toxicity; eed for testing and evaluation with each pest species.

Economics of Pest Management: identification of economic constraints on animal damage control; consideration of crop protection as an integral part of agricultural production; economic thresholds; benefit/cost ratios; determination of labor and material costs for

various pest management strategies

Research Procedures: problem definition and objectives; hypotheses and planning; experimentation and evaluation; data analysis and reporting

Behavior: instinct, learning, experience, and adaptation in relation to pest situations; senses of birds and rodents; observation of pests; role of behavior study in development of control methods.

Food Habits of Birds and Mammals: feeding behavior; food selection and preferences; prevalence of varied diets among pest species; review of anatomy of digestive systems of birds and mammals; outline of methods for studying food habits.

Animal Care: capture and handling of experimental animals; caging and sanitation; diet and food consumption; acclimatization to laboratory conditions; requirements for breeding; experimental considerations.

Damage Assessment: role of damage assessment in control methods evaluation and in pest management programs; variability and interpretation of estimates; random and stratified sampling; generalized procedures for rice, corn, and sugarcane.

Identification of Rats: review (by local scientist) of taxonomy and characteristics of local species; importance of pest identification; preservation techniques; sources of information or help with identification of unknown pests.

Baits and Bait Applications -- Rodents: problems and experimental approaches; types of baits; prebaiting; construction and use of

bait stations; formulation; methods of baiting and bait exposure; application rates; laboratory and field evaluation.

Baits and Bait Applications --Birds: special considerations in baiting for birds; bait preparation; prebaiting; designing species specificity by control of particle size, bait material, and placement; dilution baiting; aerial baiting; research and evaluation.

Rodent and Bird Problems in Storage: recognition of storage problems -- losses, waste and contamination; difficulties of monetary assessment; misplaced blame -- spillage and handling losses; reductional techniques, safety considerations, rodent and bird proofing, sanitation.

Community Programs: advantages of area-wide programs; cost reductions by quantity purchase and preparation of material; reduction of perimeter effects, control in non-agricultural reservoir habitats; problems of financing; population reduction vs. crop protection; need for individualized approaches in some agricultural settings; need for evaluation.

Regional Problems and Research Approaches: similarities and differences in vertebrate pest problems in S.E. Asia; overlap in species, crops, damage patterns, and current control procedures; variability in agricultural patterns, local ecology, and cultural factors; need for adaptive research; consideration of means for information exchange.